Thorium and thorium-plutonium fuel research in Belgium

Thomas Cardinaels, Brian Boer and Marc Verwerft

Belgian Nuclear Research Centre (SCK•CEN), Institute for Nuclear Materials Science, Boeretang 200, B-2400 Mol, Belgium

Although Belgium does not have any natural uranium and thorium resources, it has seven nuclear power plants (NPPs) which provide the country with ca. 50% of its electricity supply. The Belgian Nuclear Research Centre (SCK•CEN) plays a significant role in the safe operation of the Belgian NPPs (e.g. the monitoring of ageing processes of nuclear reactors) and is as such an indispensable part of our society. Besides the safety of nuclear installations, SCK•CEN's research is focussed on the well-considered management of radioactive waste and human and environmental protection against ionising radiation.

In 1963, with a first PWR irradiation of uranium-plutonium MOX fuel in BR3, SCK•CEN stood at the cradle of MOX fuel development and has continued, together with Belgonucleaire, the research, development and licensing of MOX fuel for both FBR and LWR applications. In 1999, SCK•CEN embarked also in thorium-plutonium studies for LWRs, and since then, thorium-based fuels have continuously been studied in all of their aspects. Fuel fabrication, in-reactor performance, safety studies, spent fuel behaviour (final disposal context) and post-irradiation examinations (PIE) were conducted. This research was mainly performed throughout two consecutive EU Framework Projects, OMICO (standing for "Oxide Fuels – Microstructure and Composition Variations") and LWR-DEPUTY (standing for "Light Water Reactor fuels for Deep Burning of Pu in Thermal Systems").

After more than ten years of in-reactor research, it is clear that thorium-plutonium MOX is a viable oxide fuel and substantial reference datasets (radiochemical, in-pile behaviour, PIE) have already been obtained. Today, in-reactor performance of thorium-plutonium MOX fuel at industrially-relevant burnup has been achieved in our BR2 reactor, and irradiations will continue in 2016, after BR2's current refurbishment. Studies of the most important fuel fabrication issues, such as feed powder aspects and sintering of thoria-based fuel pellets have been performed and will continue in collaboration with universities and industrial partners.

To become one day a real alternative for conventional uranium-plutonium MOX, there are still important hurdles to be taken. At the front end, industrialisation of the fabrication route must be explored. Larger scale demonstration of thorium-plutonium lead rods and lead assemblies using power reactors must be performed. At the back end, many of the questions concerning both disposal and reprocessing remain largely unanswered.